



ANALYZING INDIAN SECTOR SELECTION PROBLEM AMIDST CORONAVIRUS DISRUPTION: AN AHP APPROACH

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Abstract

As China's position in the market weakens due to coronavirus disease, supply chain managers around the world are looking for alternatives to safeguard their businesses. India with its strategic location, infrastructure and growing economy poses as a great option. There are several sectors in India which are performing exceptionally well and can tap into the opportunity and showcase their prowess in stabilizing the disruptions caused in the global supply chains. However, to cater to the global demands, these sectors need more development which in turn requires investments from the government. The challenge of limited resources at hand, which sector should the Indian government prioritize in the near future is a problem with which it grapples. The present study aims at creating a decision-making framework using Analytical Hierarchy Process (AHP) to solve this problem. The three-layer AHP framework, through pairwise comparisons, aims at identifying the sector which the government should focus its investments upon based upon various performance parameters. The AHP framework suggests pharmaceutical as the most preferred alternative sector amongst all. Chemical and agriculture come the next best alternatives after pharmaceutical. The managerial implications and future scope of the study are discussed in the paper.

Keywords: Supply chain management, resilience, disruptions, coronavirus

INTRODUCTION

The global business environment of the 21st century is characterized by supply chain complexities and business uncertainties. Supply chain managers are outsourcing non-core activities to increase efficiencies at the cost of vulnerability in their supply chains (Haldar et al. 2012). Whether the vulnerability is in the form of a natural disasters or terrorism or fire at the supplier's factory, the increased interconnectedness between organizations globally has augmented the potential effects of disruptions to be proliferated throughout the supply chain (Lam & Bai, 2016). The recent disruption to be causing havoc in the businesses around the globe is that of the outbreak of novel coronavirus disease from China which has also taken several lives around the globe. With China housing tier-1 suppliers of several MNEs and is the chief exporter of raw materials to several countries, the disease has affected businesses to the tune of several billions' loss (dun&bradstreet, 2020). As China's position in the market weakens, supply chain managers around the world are looking for alternatives to safeguard their businesses. India with its strategic location, infrastructure and growing economy poses as a great option. There are several sectors in India which are performing exceptionally well and can tap into the opportunity and showcase their prowess in stabilizing the disruptions caused in the global supply chains. However, to cater to the global demands, these sectors need more development which in turn requires investments from the government. With limited resources at hand, the choosing a particular sector is a problem before the Indian government.

STRIKING OF THE DISRUPTION CALLED CORONAVIRUS

In late 2019, a novel coronavirus was identified as the cause of an outbreak of acute respiratory illness in Wuhan, a city in China. In February 2020, the World Health Organization (WHO) designated the disease COVID-19, which stands for coronavirus disease 2019. In less than a month, there have been hundreds of deaths and thousands of people got infected globally. Since the first reports of COVID-19, infection has spread to include more than 70,000 cases in China and scattered but increasing cases worldwide, prompting the WHO to declare a public health emergency in late January 2020 (McIntosh, 2020). Like the other coronaviruses, this new strain originated with animals. Many of the infected individuals either worked or frequently shopped in the Huanan seafood wholesale market in the center of the Chinese city, which also sold live and newly slaughtered animals (MERS-CoV or Middle East Respiratory Syndrome and SARS-CoV or Severe Acute Respiratory Syndrome) (McCrea, 2020). Scientists around the world are still making sense of the outbreak of the novel coronavirus in China and understanding of the disease is evolving. While there are still a large number of unknowns and a race for a cure is on, multiple experts have said it is likely that the outbreak could turn into a global pandemic (Later, World Health Organization classified the outbreak as a pandemic). Harvard epidemiologist Marc Lipsitch has estimated the virus could infect 40-70% of the global population. Gabriel Leung, chair of public health medicine at Hong Kong University has said that the virus could infect 60% of the global population. With a fatality rate

between 1% and 2%, the world could be staring at an alarming situation unless the spread is contained (Singh, 2020). As of late February, 2020, the virus seems to be spreading fast to the west as it takes Europe, the Middle East and other parts of the world in its captivity. There has been an increase in the number of cases from Italy, Thailand, and Brazil etc. while countries are feeling the pinch as they hurry to bring back their citizens from the virus infected area (Aljazeera, 2020). To combat the spread of the virus, China moved swiftly to identify the reservoir, communicate with other nations, extend the Lunar New Year celebration and ban travel in and out of 14 cities, among other measures. These precautions have most likely prevented the virus from spreading further but have impacted businesses globally as they struggle to navigate uncertainty. Although the outbreak is being compared to the 2003 SARS outbreak, China is now much more developed and integrated with the global economy and the country has significantly improved its transportation networks. This means the implications for supply chains are global in nature and will be felt across a number of industries. Travel restrictions, shortages in labor and materials, as well as logistical challenges through tightened controls and hub and border closures may cascade and augment the impact much further today than it did 17 years ago (Köse, 2020). As global leaders and health officials track the strain and make decisions regarding containment, supply chain leaders are assessing and planning for how the virus could impact global supply chains and how they can minimize the losses.

The research work aims to develop a decision-making framework using Analytical Hierarchy Process (AHP) to solve this problem. The objective of three-layer AHP framework, through pairwise comparisons, is to identify the sector which the government should focus its investments upon based upon various performance parameters. The rest of the study is structured as follows: first a brief about the disruption has been discussed along with its consequence on global supply chains and opportunities to India. The literature review is then presented followed by the methodology and decision-making framework. The managerial implications and future scope of the study are analyzed at the end of the paper.

GLOBAL SUPPLY CHAINS AFFECTED

“When the local supply chain sneezes, the global processes catch cold”.

This phrase is gradually becoming true for global supply chains as the coronavirus disruption continues in China as it is the world’s factory and makes around 90% of the world’s 300 million computers a year, 70% of the 2 billion phones and 80% of the 110 million air conditioners sold globally (Singh, 2020). Besides this, it is also the leading exporter of chemicals, toys, automobiles, garments etc. which is making the matter

worse for several of the MNEs. The gravity of the situation can be estimated from the fact that at least 51,000, including 163 Fortune 1,000 companies around the world, have one or more direct (or tier-1) suppliers in the impacted region (China’s Hubei province) and at least five million companies have one or more tier-2 suppliers in and around the epicenter of the outbreak (Singh, 2020). The problem can become worse as even a slight disruption in major supply chains commanded by multinational manufacturers could create secondary delays among their clients and suppliers lasting for months in global sectors ranging from electronics to cars (Matkar, 2020). As global leaders and health officials track the strain and make decisions regarding containment, supply chain leaders need to assess and plan for how the virus could impact global supply chains. This understanding can be made more comprehensive by analyzing the following essential elements of supply chain:

1. Suppliers: There is occurrence of supply shortages of raw materials or finished goods coming from or routed through logistical hubs in impacted areas. Companies outside of China are being affected as their Chinese suppliers are unable to deliver products and materials. To compound the issue, many suppliers outside of China rely on suppliers in China to fulfill their obligations to their customers. If the outbreak continues it is likely that the impact to businesses globally will grow and that companies around the world will experience strain as their Chinese partners in the service industry are unable to make payments on invoices. For example, Vietnam’s manufacturing sector is suffering supply chain problems caused by the coronavirus epidemic which may delay production of Samsung Electronics’ new phones (PYMNTS, 2020). Its Ministry of Industry and Trade has said “Vietnam relies much on China for materials and equipment, which makes the country become vulnerable when such an outbreak happens”. To counter this vulnerability, Vietnam also eased some health-related restrictions on cross-border trade to prop up economic activity, but some strict measures are still in place.

2. Logistics: Established hubs and supply networks are experiencing limitations in capacity and availability so that even if materials are available, they are not easily transported. Finding alternative routes and means of transportation is a challenge (Köse, 2020). Closed-off ports and delayed shipments from China are not only affecting Chinese workers and companies but also their trading partners overseas who depend on supplies to keep business running. Travel restrictions to certain areas also limit the ability to discover, qualify and certify new business or programs and to transact business. With the containment of travel and the implementation of quarantine zones, trade is disrupted. Normal demand patterns are disrupted. Exporters to China also face diversions as clients there use force majeure clauses in their contracts to walk away from commitments to buy cargoes.

3. Labor: Availability of white- and blue-collar labor is getting limited due to quarantine guidelines or illness. China's factories normally ramp up production right after the Lunar New Year but few workers have returned this year. Most of China's migrant workers who number some 300 million, remain cloistered in sealed-off villages and towns. Those who do manage to leave find themselves barred from renting places to stay near their workplaces by landlords fearful of travelers. In Kunshan, a city that is home to many migrant workers near Shanghai, labor shortages are glaringly evident. The city is home to massive factories operated by Foxconn and Pegatron, the titans of global electronics manufacturing and key suppliers for companies such as Apple. Even a slight disruption in major supply chains commanded by multinational manufacturers like Foxconn and Pegatron could create secondary delays among their clients and suppliers, lasting for months in global sectors ranging from electronics to cars. Organizations are also not getting approval to begin work owing to hygiene requirements.

4. Consumer Demand: Consumers may be more cautious in their purchasing habits due to fears about being in public and potential exposure to the virus. Many may turn to online sales, straining logistics networks. The famous Bullwhip Effect may also be a key aspect of potential supply chain problems. As companies over-react to falling demand signals, companies further back in the supply chain can see orders from their customers drop dramatically and many small but essential component manufacturers could be in danger of failing, Sheffi says. When demand recovers, a reverse Bullwhip Effect can take hold, with overly aggressive orders up and down the chain, with many suppliers then struggling to keep up (SupplyChainDigest, 2020). Also, as China is the largest consumer, the wide-spreading Coronavirus has impacted several commodities prices including base metals, oil etc., which ultimately helped many companies in their earnings (Matkar, 2020)

While it is difficult to see what the impact (of the virus outbreak) may be, it is important to see where the opportunity may lie. Companies should analyse their and their international competitors' supply chains and see what new places could be occupied.

INDIA'S OPPORTUNITIES TO THE DISRUPTION

The coronavirus disruption has hit global trade and manufacturing in China and round the globe thanks to the coronavirus has opened up an opportunity for India to try and woo global biggies. The MNEs around the globe have been hit big either because of tier 1 suppliers getting affected or labor shortages or their shipments are stuck at the port. But every crisis has its own silver lining and there appears to be a big economic opportunity which can be tapped by Indian sub-continent in various sectors. For example, IOL Chemicals and

Pharmaceuticals Ltd., the world's biggest producer of ibuprofen is set for its best month in more than two years as the prolonged shutdown of China's Hubei province boosts prices of the non-prescription painkiller. The resulting supply gap because of the disruption is the cause of benefit which is visible in the form of increase in revenue and export share (Joshi, 2020). The outbreak of the novel coronavirus in China, the factory of the world, could be, hence, seen as an opportunity to obtain new markets and to relook at risk management for Indian manufacturing. One of the several sectors which have the potential to grow amidst the coronavirus is the Chemical sector. India can gain from chemical exports to China. The Hubei province which is the epicenter of the outbreak is a leading chemical producer. Closure of the industry may be utilized. This can be seen from the fact that six Indian chemical stocks tracked by the brokerage — Galaxy Surfactants, Fine Organic Industries, Navin Fluorine International, SRF, PI Industries and UPL, have beaten the market in recent years, helped by robust growth in end-user industries and exports to China, which has closed many chemical facilities on environmental concerns (Shirodkar, 2020). Similarly, India can also take up the space in the apparel sector that has been left vacant by China due to the shutdown which is to the tune of \$20 billion. The domestic textile and apparel industry, including handicrafts, stood at \$140 billion in 2018, of which \$100 billion was domestically consumed while the remaining portion worth \$40 billion was exported to the world market. Make in India program can also see a big acceleration (First Post, 2020). India comes second, after China, when it comes to exports of gems and jewelry which can be elevated as India takes advantage of the gap left by China. There are several markets which India can tap for cut and polished diamonds, gold jewelry products, colored gems and imitation jewelry. Furthermore, the agriculture and aquaculture sector of India can also strive to increase its exports to nations as China's exports have suffered a setback.

The huge disruption in global trade and manufacturing in China thanks to the coronavirus has opened up an opportunity for India to try and attract global MNEs to put India at a stronger position. With trade deficit ballooning, India can aim to have manufacturing hubs and easier regulations to attract global electronics MNEs to manufacture locally. With global smartphones export market around \$300 bn—60% of this is done out of China and 10% out of Vietnam- the key here is to bring big and leading MNEs (Jain, 2020). Greater tax incentives or free land or some other facility from the government's end can help firms to scale up and get more efficient and can help in gaining exports. The Table 1 discusses the various aspects of the Indian sectors which characterize the supply chain of these sectors based on performance parameters

Table 1: Characteristics of Indian sectors based on various performance parameters

Indian sectors ↓ → Parameters	Indian Sectors Characteristics				
	Pharmaceutical	Apparel	Chemical	Agriculture	Aquaculture
Flexibility	Inefficient processes and compliance issues affect the reliability of supplies	Significant presence of small suppliers and abundant availability of raw materials	Logistics cost as significant costs with vulnerability to fluctuations in oil and gas prices adding to woes	Strategic geographic location and proximity to food importing nations and promising opportunities in storage facilities	increase in working capital requirements owing to seasonality in cropping
Cost	The cost of manufacturing formulations in India remains 30-40 percent lower than other comparative manufacturing hubs such as China despite low productivity levels	Low cost of plant and machinery makes manufacturing units viable at all scales. India also enjoys a comparative advantage in terms of skilled manpower and cost of production relative to major textile producers	Different segments of the industry entail different costs. Basic has high feedstock and raw material costs (low profits) while specialty has high selling and product development costs. Higher costs of finance and poor infrastructure translate into higher costs	India benefits from a large sized agriculture sector, abundant livestock, high returns and cost competitiveness	Fragmented due to its labor-intensive nature. Lack of cold storage leads to high costs hence lower their bargaining power.
Research and Development	World-class capabilities in formulation development, the entrepreneurial ability However, low margins constrain the players to invest in R&D	Investment required to promote modernization and up-gradation of the textile industry by providing credit at reduced rates	The government offers several incentives to promote R&D but lack of skills and necessary funds have limited the investments	Investment opportunities in R&D to arise in agriculture, food infrastructure and contract farming	Various incentives provided by the government incentivize the different facets to be explored for research and innovation
lead time	India continues to rely on imports of key starting materials, intermediates and API's with the share of dependence increasing over time.	Strong production base of wide range of fiber / yarns from natural fibers like cotton, jute, silk and wool to synthetic / man-made fibers like polyester, viscose, nylon and acrylic	Lack of infrastructure, technology and capacity bottlenecks	With growing investments in irrigation, the dependence on monsoons has declined considerably over the years	The sector faces numerous infrastructure challenges like modernization, hygienic fish handling facilities robust food safety compliant mechanism in domestic wholesale or retail markets
Technology	Firms need to consider shifting to IR 4.0 technologies which shaves valuable startup capital costs and helps pharma companies build sounder businesses	Technology Upgradation Fund Scheme (TUFs) covering all manufacturing segments of the industry	Manufacturing plants were earlier built to meet the local demand and were small and uncompetitive were small as compared to global scales and did not necessarily employ state of the art technology. Today, these legacy plants make Indian chemical industry uncompetitive	Both domestic and global firms have been focusing on product innovation to cater to domestic tastes, Crop protection, soil enhancement, increased productivity are the major segments for the industry	There is a strong need to come up with innovative & cost-effective transportation and storage facilities to ensure supply of superior product to the consumer.

THE SECTOR SELECTION PROBLEM

There is no denying the fact that China is the world's factory implying that most of the raw materials and labor requirements for basic products are fulfilled from China. From automobiles, electronics, pharmaceuticals, chemicals, aquaculture, China has become an indispensable part of the world's global supply chains. With China getting affected by disruption caused by the outbreak of Coronavirus most of the global supply chains, whose tier-1 suppliers and manufacturing units were present in China, have also been affected. Besides affecting the raw material supplies all over the world, the labor shortages in China has also halted production work. Even a slight disruption in major supply chains commanded by multinational manufacturers could create secondary delays among their clients and suppliers, lasting for months in global sectors ranging from electronics to cars. These conditions have compelled the supply chain managers to look for alternatives as quickly as possible so as to prevent their companies going in the red. India, with its growing infrastructure availability, labor and regulations pose as an attractive alternative to the space left vacant by China. Several sectors of India such as apparel, chemicals, pharmaceuticals etc. have tremendous potential to compete and expand. The need is to attract the big players in various sectors so that exports start increasing by themselves. This brings in the increasing role of the government in providing incentives in tax, introducing R&D centers and putting in more resources so that firms scale up and get more efficient. However, with Indian government grappling with dwindling economic conditions and as it prepares itself to fight coronavirus, the resources with the government are limited. With limited resources at hand, which sector should the Indian government prioritize in the near future is a problem that grapples the government. At present, the government needs to invest its resources and provide benefits to the sector which is best performing and

have been least affected by the disruptions. Such an attempt consequently improves the attractiveness of the sector for the supply chain managers that are managing global supply chains and are looking for viable alternatives to China. The selection of sector (or alternatives available to the government) is based on several aspects (or criteria) which makes it a multi criteria decision making problem. In this case, the researcher shall be solving this problem by application of Analytical Hierarchy Process (AHP) method. Previously, sector selection has been performed for ERP implementation to achieve most impact on supply chain performance and the researchers had used AHP-TOPSIS methodology (MCDM method) for this purpose. Here the performance indicators were used for sector selection and were derived from the SCOR model and included metrics related with in-bound/out-bound logistics success, service levels/accuracies, delivery times, cycle-times at different levels. Another sector selection process entailed co-creation between technology providers, product developers and users in order to make needs and solutions emerge, user profile, business model and territorial anchoring. The current case entails prioritizing a sector at the time of a disruption. The ultimate goal of effective risk management is to create robust and resilient supply chains (Strozzi and Colicchia, 2012) potentially impacting operational performance. To this end, researchers have reviewed the supply chain literature and suggested directions for research on supply chain performance measures, which should include criteria on efficient resource allocation, output maximization, and flexible adaptation to the environmental changes (Beamon, 1999). A few of the categories in the literature, including: quality, time, flexibility, and cost have also been developed (Narsimhan & Talluri, 2009). Based on the study of literature, the performance criteria of a sector are being used as criteria for prioritizing the sectors. The criteria decided upon are technology, cost, flexibility, lead time and research and innovation (Table 2).

Table 2: Description of criteria used in the problem

Name of the Criteria	Definition
Flexibility	Flexibility may be defined as the ability to change or react with little penalty in time, effort, cost or performance
Lead Time	The time from the moment the customer places an order to the moment it is received by the customer. Competitors that cannot deliver products and services within the established lead time will likely to perish (Agarwal et al., 2006; Kader and Akter, 2014).
Cost	SCC is the cost for handling the supply chain area, that is, the entire supply chain controlled by the company. It is suggested that SCC be divided into five main areas plus a sixth area that is applicable for supply chains where installation costs are a necessary part and included in the sales price. The six areas are manufacturing costs, administration costs, warehouse costs, distribution costs, capital costs and installation costs (Pettersson & Segerstedt, 2013).
Technology	Supply Chain Technology (SCT) is a business enabler that has led to the growth of e-supply chains as it enables firms to collaborate and compete. The SCT coordinates the production and operations activities, logistics and processes within supply chains. This SCT can be either functional SCT that supports specific functional areas of the firm's supply chain or the integrative SCT that allows the firm to interact with all its partners in the supply chain. Both the integrative and functional SCTs play a crucial role in linking all aspects of the supply chain (Magutu et al., 2015)
Research and Innovation	An innovation activity may be defined as scientific, technological or financial steps which are intended to or lead to implementation of innovation. A firm's internal R&D is an innovation activity complimentary to knowledge acquisition (Chan et al., 2014)

APPLICATION OF AHP METHODOLOGY IN SECTOR SELECTION PROBLEM

The present problem is multi criteria decision making problem. The AHP, originally developed by Saaty (1971), is a powerful tool for multi-criteria decision-making under uncertainty. With AHP complex decision problems can be broken down into a set of manageable pairwise comparisons, aiding decision makers to arrive at the best alternative. Usually, AHP is being employed with the following four steps (Saaty, 1971):

1. Construct the decision hierarchy: the decision is decomposed

into its independent elements;

2. Determine the relative importance of attributes and sub attributes: pairs of attributes are evaluated on a nine-point scale (Table 3);
3. Evaluate the performance of each alternative: the relative performance of alternatives is evaluated with respect to each attribute on a similar nine-point scale; and
4. Check the consistency of the subjective evaluations.

Table 3: Nine-point pairwise comparison scale (adapted from Saaty, 1971)

Numerical value	Verbal meaning of criteria evaluation (step 2)	Numerical value	Verbal meaning of criteria evaluation (step 2)
1	Equally important	6	Strongly to very strongly more important
2	Equally to moderately more important	7	Very strongly more important
3	Moderately more important	8	Very strongly to extremely more important
4	Moderately to strongly more important	9	Extremely more important
5	Strongly more important		

The power of AHP is especially useful when hard-to quantify, qualitative, or uncertain aspects need to be assessed, which is the case in our situation (the assessment of five offshoring alternatives and their associated risks). Compared to a pure financially oriented approach, AHP can thus easily incorporate immaterial consequences, for which no hard numbers or monetary values can be determined in a straightforward fashion. Specifically, within this context, AHP has been described as “a promising technique, which reduces the complex and error-prone risk assessment process to a series of straightforward one-to-one comparisons” along a standard nine-point scale. This study focuses on the application of AHP to prioritize government’s resources on sectors for them to become part of those global supply chains which have been disrupted by the recent outbreak of coronavirus. The alternative sectors have been identified by the researcher after analysis of quantum of exports done by India in comparison with that of China. After analysis of trade maps, trade reports etc. Following five sectors namely, pharmaceuticals, apparel, Chemicals, agriculture and aquaculture have been selected.

PHARMACEUTICAL

The Indian pharmaceuticals market is the third largest in terms of volume and thirteenth largest in terms of value. It has established itself as a global manufacturing and research hub. A large raw material base and the availability of a skilled workforce give the industry a definite competitive advantage. The Indian pharmaceutical industry is expected to grow at a compound annual growth rate (CAGR) of 22.4 percent to touch US\$ 55 billion by 2020. Pharmaceutical (Includes Bulk Drugs, Drug Intermediates, Drug formulations, Biologicals, Ayush and Herbal Products and Surgical export from India stood at US\$ 19.13 billion in 2018-19 and reached US\$ 9.36 billion in 2019-20 (till October 2019). These statistics are in comparison

with the export numbers of China which shows that India has immense potential of covering the gap (DGCIS, 2019).

- It is expected to grow by 30 per cent to reach US\$ 20 billion by the year 2020.
- In 2018-19, top importers of India’s pharmaceutical products were USA (US\$ 119.18 million), Russia (US\$ 10.33 million), UK (US\$ 9.83 million), South Africa (US\$ 3.63 million) and Nigeria (US\$ 1.71 million).
- India is expected to rank amongst the top three pharmaceutical markets in terms of incremental growth by 2020.
- India is the largest supplier of generic medicines globally (20 to 22 percent of global export volume)
- India has one of the lowest manufacturing costs in the world. It is lower than that of the USA and almost half of Europe.

APPAREL

Indian textiles and apparels have a history of fine craftsmanship and global appeal. Cotton, silk and denim from India are highly popular abroad, and with the upsurge in Indian design talent, Indian apparel too has found success in the fashion centers of the world. India is the world’s second-largest exporter of textiles and apparel, with a massive raw material and manufacturing base. The textile industry is a significant contributor to the economy, both in terms of its domestic share and exports. It contributes about seven per cent to industry output, two per cent to the GDP and 15 per cent to the country’s total exports earnings. The sector is one of the largest sources of job creation in the country, employing about 45 million people directly. Ready Made Garment Exports were to the tune of USD 1451.00

million in January, 2020. Cumulative RMG exports in dollar terms during April-January, 2019-20 is USD 12896.21 million registering a positive growth of 0.15 %. (CSO, 2019)

CHEMICALS

Basic chemicals and their related products (petrochemicals, fertilizers, paints, varnishes, glass, perfumes, toiletries, pharmaceuticals, etc.) constitute a significant part of the Indian economy. Among the most diversified industrial sectors, chemicals cover an array of more than 70,000 commercial products. India is the sixth largest producer of chemicals globally and third largest producer in Asia in terms of output. The country ranks third globally in the production of agro chemicals and contributes around 16 per cent to the global dyestuff and dye intermediates production. In fiscal year 2019, India exported chemicals and its products valued at more than three trillion rupees. This was a significant growth from the previous fiscal year. This sector contributed nearly 13.3 percent to all exports from the country (statista, 2019). The promotion of product groups such as dyes and dye intermediates, basic inorganic and organic chemicals, including agro-chemicals, cosmetics, toiletries, essential oils, incense sticks, castor oil and its derivatives, is handled by the Basic Chemicals, Cosmetics & Dyes Export Promotion Council, which is popularly known as CHEMEXCIL (CHEMEXCIL, 2019).

AGRICULTURE

India's agrarian culture and varied regional climate have significantly contributed to the global food basket.

Indian curries, mangoes, snacks and spices are known for their excellent quality across the globe. Globally, India leads the following food segments:

- India stands first in the production of bananas papayas and mangoes. During 2018-19*, 31.74 million tonnes of banana, 5.98 million tonnes of papaya and 20.79 million tonnes of mango were produced in the country.
- During 2018-19*Guava production amounted to 4.23 million tonnes.
- India is the largest milk producer in the world (176.3 million tonnes)
- India has the largest buffalo population (108.7 million)
- India is the largest pulses producer in the world (23.40 million tonnes) (4th AE 2018-19)
- Among vegetables, India ranks second in world (185.88 million tonnes), and first in the production of Okra (6.17 million tonnes)

In FY19, exports of agricultural and processed food products totaled US\$ 38.49 billion. During the period, top exported commodities were basmati rice (US\$ 4.72 billion), buffalo meat (US\$ 3.60 billion) and non-basmati rice (US\$ 3.04 billion). During April-September 2019, export stood at basmati rice

(US\$ 2.03 billion), buffalo meat (US\$ 1.6 billion), non-basmati rice (US\$ 1.01 billion) and miscellaneous preparations (US\$ 308.6 million). Indian agricultural/horticultural and processed foods are exported to more than 100 countries/regions; chief among them are the Middle East, Southeast Asia, SAARC countries, the EU and the US (APEDA, 2019).

AQUACULTURE

Indian fisheries and aquaculture are an important sector of food production providing nutritional security, besides livelihood support and gainful employment to more than 14 million people, and contributing to agricultural exports. With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, the country has shown continuous and sustained increments in fish production since independence. The total fish production during 2017-18 is estimated to be 12.60 million metric tonnes, of which nearly 65% is from the inland sector and about 50% of the total production is from culture fisheries, and constitutes about 6.3% of the global fish production. Paradigm shifts in terms of increasing contributions from inland sector and further from aquaculture have been significant over the years. With high growth rates, the different facets, viz., marine fisheries, coastal aquaculture, inland fisheries, freshwater aquaculture, and cold-water fisheries are contributing to the food basket, health, economy, exports, employment and tourism of the country. More than 50 different types of fish and shellfish products are being exported to 75 countries around the world. Fish and fish products have recently emerged as the largest group in agricultural exports from India, with 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value. This accounts for around 10% of the total exports and nearly 20% of the agricultural exports, and contributes to about 0.91% of the GDP and 5.23% to the Ag - GVA of the country. With over 2.4 lakh fishing crafts operating along the coast, 7 major fishing harbors, 75 minor fishing harbors and 1,537 landing centers are functioning to cater to the needs of over 4.0 million fisher folks. To promote aquaculture, 429 Fish Farmers Development Agencies (FFDAs) and 39 brackish water Fish Farms Development Agencies (BFDAs) were established in the country. The annual carp seed production is to the tune of 40 billion fry and that of shrimp is about 54 billion PLs, with increasing species diversification in the recent past. Besides large-scale freshwater food fish culture, ornamental fish culture and high value marine fish farming are gaining importance in the recent past.

DECISION HIERARCHY

The decision hierarchy is a graphical representation of the decision goal, the main objectives, the sub-objectives, the risk factors (attributes), and the alternatives. This hierarchic representation and decomposition represent a succinct summary of the decision problem at hand. For the current case, the framework is presented in Fig. 1 For clarity of presentation, links to and from the risk factors and alternatives have been omitted in the decision hierarchy.

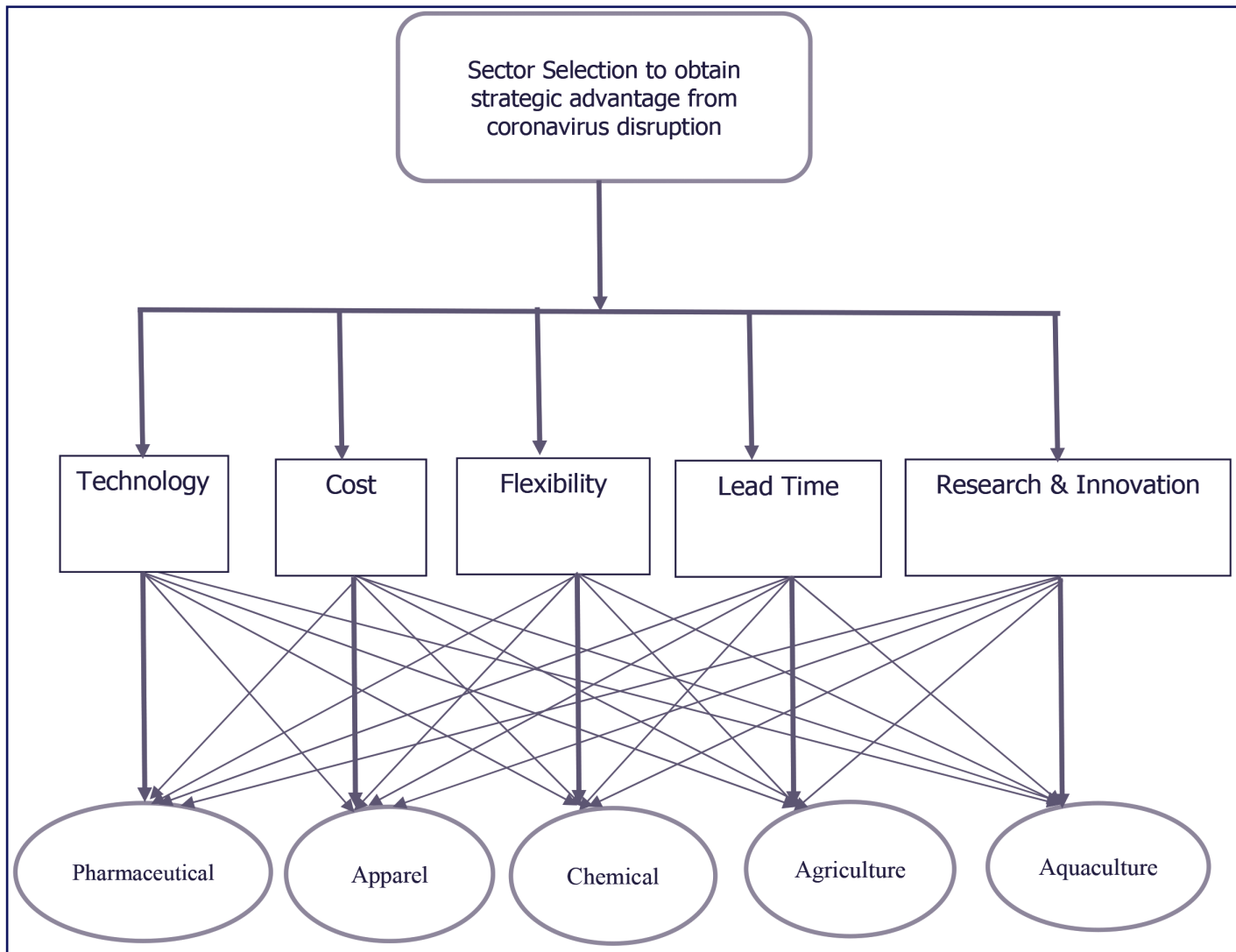


Figure 1: AHP Framework for Sector Selection

IMPORTANCE OF CRITERIA PERFORMANCE FACTORS

To determine the relative importance of the performance factors, the research team subjectively evaluated pairs of these factors (attributes) on a nine-point scale (Table 3). Overall, 25 pairwise comparisons were conducted, which are presented in

the appendix. The final weight for each risk factor, representing its relative importance is provided in Table 4. For making pairwise comparisons, a sample of 5 experts having more than ten years of experience in the area of supply chain management has been identified. A detailed note on supply chain and background material on sector selection problem have been circulated among the experts.

Table 4: Importance of criteria performance parameters

	Technology	Cost	Flexibility	Lead Time	Research	e-vector
Technology	1	4	0.5	3	2	0.238081
Cost	0.25	1	0.166667	0.25	0.111111	0.037462
Flexibility	2	6	1	7	4	0.463614
Lead Time	0.333333	4	0.142857	1	0.5	0.0905
Research	0.5	9	0.25	2	1	0.170343

EVALUATION OF ALTERNATIVES

The evaluation of the five alternatives was conducted in a similar fashion as the comparisons among the performance

factors: 5 (because we have five alternatives) matrices were created with the rows and columns being labeled with the five alternatives (Table 5 shows comparison based on Technology).

Table 5: Importance of Sectors with respect to performance criteria: Technology

Technology	Pharmaceutical	Apparel	Chemical	Agriculture	Aquaculture	e-vector
Pharmaceutical	1	3	0.333	2	5	0.2296
Apparel	0.333	1	0.143	0.25	0.333	0.0479
Chemical	3	7	1	4	3	0.4377
Agriculture	0.5	4	0.25	1	4	0.1664
Aquaculture	0.2	3	0.333	0.25	1	0.0796

Consistency Check

A total number of 150 pairwise comparisons were conducted (25 comparisons to develop the weights for the criteria, 125 comparisons to develop the weights for each alternative's performance relative to the criteria), one can easily make mistakes and inconsistencies can slip into the evaluation. Whether such inconsistent evaluations have been made which can be assessed via the consistency ratio (CR) developed by Saaty (1971), which was calculated for each of the comparison matrices. For the measure of CR, consistency index (CI) is first calculated which measures the deviation or degree of consistency.

$$CI = \frac{\lambda_{max} - 1}{n - 1}$$

$$CR = \frac{CI}{RI}$$

Knowing the consistency index, consistency ratio is calculated by comparing CI with random consistency index. The random consistency index (RI) is the average value of CI for random matrices using the Saaty scale. The ratio of CI and RI gives consistency ratio whose value should be less than or equal to 0.5 for consistency. Here the CR values for the comparison are below 0.5 (see appendix) which prove the consistency in results. If the value is greater than 0.5, then the matrix is considered inconsistent and experts need to be contacted again.

Table 6: consistency ratio of each of sector pairwise comparison

Name of the sector	Consistency ratio of sector pairwise comparison
Technology	0.436
Cost	0.452
Flexibility	0.387
Lead Time	0.257
Research	0.414

FINAL AHP RESULTS

While the earlier results offer interesting and valuable insight, the main goal of the AHP evaluation was to determine the best sector alternative. The final weights provide information about the relative performance of the five alternatives across

each risk factor; higher values signify more favorable relative performance. These weights for each alternative, are presented from highest to lowest in Table 7. The most preferred alternative sector amongst all is pharmaceutical. Chemical and agriculture are the next best alternatives after pharmaceutical.

Table 7: Final AHP results

Criteria	Technology	Cost	Flexibility	Lead Time	Research	Final Priority Weights
Sectors	0.238	0.037	0.463	0.0905	0.170	
Pharmaceutical	0.2296	0.3695	0.3239	0.3608	0.4532	0.3568
Apparel	0.0479	0.1072	0.0726	0.0452	0.0360	0.0644
Chemical	0.4377	0.2381	0.26996	0.3198	0.2296	0.3326
Agriculture	0.1664	0.0616	0.0767	0.1335	0.1571	0.1263
Aquaculture	0.0796	0.1098	0.1307	0.0914	0.1088	0.1199

DISCUSSION AND MANAGERIAL IMPLICATIONS

The coronavirus outbreak in China and now in the entire world had affected global supply chains of several multinational organizations. China is known to be the world's factory with several companies having their tier-1 suppliers stationed there. With this disruption, the supply chains of these organizations have also been affected and they are looking for alternative

countries to counter this disruption. With India at its strategic location and resources at par with China, can prove to be one of the alternatives. This shall not only be beneficial to Indian economy but also help the affected organizations normalize the disruptions. One of the motivations for this study was to aid the government to select a sector in which investments can be made to not only lift the Indian economy but also to counter the disruptions caused by coronavirus. There are several sectors

of India which are at par in exports as China and hence can become alternative destinations of raw materials for several of the affected global supply chains. This study aims at identifying those sectors based on their performance on several criteria namely technology, cost, flexibility, lead time and research and development. The sectors identified were pharmaceutical, chemical, apparel, agriculture and aquaculture and have been selected based on their performance in exports in comparison to China. Since there are several alternatives amongst which one sector has to be selected based on several criteria, this problem of sector selection becomes a multi criteria decision making problem which has been solved using Analytical Hierarchy Process (AHP). An additional strength of AHP lies in its ability to incorporate qualitative criteria, as well as uncertainty present in decision-making. Through several pairwise comparisons, the pharmaceutical sector has been identified to be the best bet for the Indian government to put their resources based on the sector's performance in technology, cost, flexibility, lead time and research and development. Once the pharmaceutical sector has been settled, the resources can be pooled for the chemical and agriculture sector.

However, as time goes on, alternatives have to be re-evaluated on a continuous basis, and risk factors have to be reassessed to account for potential changes that are occurring in the market environment; it is an evolving process. The AHP serves as an outstanding tool in this regard, since once the comparison matrices have been set up, they can be revisited and evaluations can be adjusted easily based on changes that may have occurred. For instance, some factors and alternatives may diminish in significance, while the importance of others may increase. Moreover, additional factors not considered in the present decision may emerge, and others may disappear completely. Having now made a successful decision, the government should not rest on its laurels, but continuously keep an open mind to identify even better alternatives that may emerge. While pharmaceutical, chemical and agriculture sectors are performing better and have emerged the best alternatives, this might change in future as other sectors become competitive.

CONCLUSION

The present study is an attempt to identify and prioritise the sectors for development due to the present disruption from the spread of coronavirus. Global supply chain managers are striving hard to identify alternative suppliers as most of their suppliers in China have stopped supplying owing to the disease. India with its strategic location, enhancement in trade regulations and growing Indian market poses as a suitable alternative for such supply chains. However, with limited resources at hand, the Indian government needs to prioritise from various sectors in which it should pool its resources. This study identified those sectors based on their performance on several criteria namely technology, cost, flexibility, lead time and research and development. These criteria were identified through extensive review of literature. The sectors identified were pharmaceutical, chemical, apparel, agriculture and aquaculture and have been selected based on their performance

in exports in comparison to China. Since there are several alternatives amongst which one sector has to be selected based on several criteria, this problem of sector selection becomes a multi criteria decision making problem which has been solved using Analytical Hierarchy Process (AHP). Based on the AHP model, the sector selected is the pharmaceutical sector. Such a study shall be helpful for the Indian government to prioritise their pool of resources and valuable time in the development of a sector which can grow fast. Once this sector is settled, development of other sectors can follow. This study can be utilized by other nations or even organisations when faced with the problem of allocation of limited resources to different cost centers and achieve effectiveness.

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